Information Sheet on
Building, Equipment, and Labor Requirements and Processing
Costs in Dehydration

ONIONS

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The construction and operation of a dehydration plant in wartime are somewhat different from a similar enterprise in time of peace. The main differences result from the scarcity of critical materials and labor. Monetary costs are a secondary consideration, whereas in time of peace they are paramount. The task in wartime is to produce the desired quantity of quality goods when needed. From the standpoint of plant construction and process the problem is largely one of engineering and technology. However, proper construction and operation of these plants are matters to study from a cost standpoint, since efficiency is best measured in terms of dollars and cents.

This discussion deals with plant layout and equipment and labor requirements, mainly from a cost standpoint. There is no intention to engineer a plant nor to advocate certain methods of processing. Engineering and technological considerations are included only in relation to the probable cash outlay for plant and the probable processing costs under the conditions as stated.

Even though the cost of the plant and equipment may appear high, it is only a minor consideration in determining the processing cost per dry pound. The day-to-day charges such as labor, raw material, packaging supplies, etc., are by far the greater. In many cases the cost of raw material, labor, and packaging supplies for only one month amount to more than the total initial investment for plant and equipment. Capital investment should, nevertheless, be given careful consideration. The type of building, kind of equipment, and plant layout are important factors in the efficient operation of any dehydration plant. A plant must be engineered so as to make the most efficient use of labor, equipment, and floor space, and to handle raw materials without damage and waste, if low operating costs are to be attained.

The various units of a dehydration plant must work together as an integrated whole. A properly planned dehydration plant is not built around a particular piece of equipment nor around a certain step in the process. The different operations must be balanced, with no "bottlenecks." To accomplish this, the capacity of each piece of equipment should be somewhat flexible so that an operating balance can be secured without seriously impairing the efficiency of any part of the plant. New plants should be completely engineered before construction begins. Otherwise, costly changes may be required later.

A series of suggested processing steps for the dehydration of onions in slices is shown in the accompanying flow sheet, figure 1. The removal of the peel is the most difficult step in the preparation of onions for drying. Many expedients are used, but it is hard to say which is best. Hand peeling is the most positive, but results in high labor costs. Abrasion peeling is used but has not been altogether satisfactory. Flame peeling has been used with some success. Other methods have been tried, but as yet there is no proved and generally accepted method.

The following discussion assumes flame or some similar type of peeling, in the larger plant sizes. This assumption is conservative from a capital cost standpoint since the flame peeler and its related equipment are probably the most expensive type of peeling apparatus. From the standpoint of labor cost, this is not so conservative, since it is assumed that the peeling machine will remove most of the skin, leaving only trimming to be done.

It should be borne in mind that if methods of peeling are used that do not remove most of the skin of the onion, the labor costs will likely be considerably higher than indicated herein. The reduced capital investment has little effect on the total processing costs. Regardless of the peeling method used, however, the flow sheet remains essentially the same.

Building Requirements

The building need not be expensive, but certain features are essential. It must have good concrete floors throughout and proper drainage so that walls and floors can be washed down and kept clean. All outside openings should be screened so that flies and other insects cannot enter, and outside screen doors should have automatic closing devices. Rodent-proof construction is highly desirable.

The plant layouts presented here show practical floor plans and will serve as guides to floor-space requirements and arrangements for the different operations. Buildings of rectangular shape are used for illustrations because they are a commonly used type. If the plant is to be located in existing buildings, the layout must be modified to take advantage of the available space in the best manner.

In some cases it may not be feasible to locate all parts of the plant within the limits of a rectangular building. Mezzanine floors and smaller adjoining buildings can be used.

A summary of the requirements of various sections of the building is given in table 1. Preferred location and other considerations are included. On the basis of actual floor space in operating plants and an objective appraisal of the adequacy of these allowances, approximate floor space requirements for various parts of the plant are given in table 2.

Figures 2 and 4 to 6 present plant layouts for dehydration plants ranging in size from a capacity of 5 to 50 tons per day, unprepared basis. The plant layout shown in figure 2 is designed for the dehydration of onions. The layouts shown in the other three figures are designed for root vegetables such as potatoes, carrots, and rutabagas, but are presented here to show for the 25-ton plants the approximate layout of a counterflow tunnel drier and a conveyor drier, and for the 5-ton plant the arrangements in a very small dehydrator. By changing the preparation lineup and making allowance for the drying capacity of the dehydrator, these layouts can be used as a base for dehydration plants handling onions.

Equipment Requirements

Preparation equipment.--Figure 3 presents the layout of the preparation line for the 50-ton plant. Both the side elevation and floor plan are shown. The line need not be straight; it can be turned at any one of a number of convenient places as illustrated in the plant layouts.

Only properly designed and carefully built machinery should be used. A poor cutter or slicer may cause damage to the product and increase washing losses, Incomplete peeling necessitates excessive trimming labor, and drastic peeling wastes the product. Improperly designed elevators, conveyors, and washers may be too rough in their action, resulting in damage to the product.

Ruggedness and long operating life are important. High initial costs are justified when they result in reduced repairs and replacements. Repairs cause grief and expense due to interruption of production and improper handling and processing.

Where there is a possibility that the stopping of any machine will interrupt the continuous flow of the product through the plant, some means of substitute operation should be available or else there should be water immersion storage facilities for the unfinished product so that it will not deteriorate. In larger plants, it may be justifiable to provide two of almost all major items of equipment not only because of the possibility of a breakdown but also from an operating standpoint. For example, two or even three trimming belts are preferable to one.

Oversized equipment may be a wise investment. Various parts of the preparation line are then able to handle increases in throughput which may occur as a result of improvement in quality of raw material or changes in labor and equipment.

On the other hand, much can be done to reduce investment in processing equipment. The number of elevators and conveyors can be reduced by placing some machines on elevated platforms directly over other machines, thus utilizing gravity flow. This also reduces the floor space required. Elimination of all unnecessary handling of the material reduces the amount of labor and equipment needed and results in a better-finished product.

TABLE 1.—General requirements for various sections of the building

Section	Preferred location	Ventilation & temperature	Other considerations
Raw material storage	Adjacent to preparation room and receiving platform.	Cool and dry.	Easily cleaned. Screened. Space for 2 to 3 days' supply of material may usually be considered minimum.
Finished product storage	Adjacent to packaging room and shipping platform.	Cool and dry.	Insect and rodent proof. Space dependent upon regularity of outgoing shipments and stock of packaging supplies required.
Preparation	Commodious part of building	Adequate ventilation, no objectionable odors.	Built-in waste flumes in floor are desirable.
Drying	So that no other activities will interfere with cars. Allow for future expansion.	Provide outside outlets for exhaust air.	Provide adequate storage space for trays and trucks. Avoid cross-traffic in movement of trays and trucks.
Packaging	Out of line of traffic. Near finishing bins and adjacent to finished product storage.	Provide dry air.	Partition from rest of building.
Laboratory	Depends on plant layout and operators' preferences.	Analytical balances and other equipment affected by changes in temperature and humidity. Room free from excessive dust.	If located near heavy pounding, such as may occur in machine shop, the analytical balances may be disturbed.
Locker and wash rooms	Near preparation room to avoid excessive traffic.	Provide outside ventilation.	
Office	Overlooking shipping and receiving platform and possibly preparation room.		
Machine shop	Near tray storage and preparation room.		Provide space for repair parts and idle equipment.
Sewerage	Near preparation room but away from other activities.	Keep air and odors from main parts of building.	Provide easy removal of waste material.

TABLE 2.--Approximate floor space requirements 1/

	5-ton plant 2/		25-ton plant 2/		50-ton plant 2/		100-ton plant 2/		50-ton plant in sketch
	Low	High	Low	High	Low	High	Low	High	
	square feet								
Raw material storage 3/	400	800	2,000	4,000	4,000	8,000	8,000	16,000	4,100
Finished product and packaging supplies storage 4/	400	800	2,000	3,500	3,000	6,000	6,000	12,000	4,000
Preparation	300	500	1,200	2,000	1,800	3,000	3,000	5,000	2,000
Drying 5/	1,500	3,000	6,000	8,000	10,000	13,000	15,000	20,000	11,750
Packaging	100	200	400	600	500	800	800	1,000	600
Laboratory	-	-	100	200	200	400	300	500	300
Locker and wash rooms	200	400	500	1,000	1,000	1,500	1,500	2,500	1,100
Office	-	-	300	500	400	600	500	750	600
Machine shop and tray repair	-	-	300	500	500	1,000	600	1,200	550
Sewerage 6/	-	-	200	300	400	600	500	1,000	-
Total	2,900	5,700	13,000	20,600	21,800	34,900	36,200	59,950	25,000

1/ The low limits of floor space will be undesirable in most instances.
2/ Capacity given in tons per 24 hours, unprepared basis.
3/ The space indicated for raw material storage will provide from 2 to 3 days' supply of root vegetables in sacks or boxes. Additional space must be provided if a larger supply of raw material is to be kept on hand. If it is not feasible to have this storage space in one building, adjoining buildings or covered platforms may be used.
4/ Additional storage space, 50 percent or more of that indicated here, should be provided on mezzanine floors or in separate buildings for storage of chemicals, spare equipment, and other items that accumulate. It is assumed here that these dehydration plants are on a war basis and finished goods are shipped as soon as shipping facilities are available. However, for normal operation in peace time, plants of the same capacity will ordinarily need much more space for storage of finished goods.
5/ Floor space allowances for the dehydrator are based upon truck and tray tunnel driers.
6/ In many instances no space will need to be allocated for sewerage. Space indicated here is for settling and separation of solids from liquid wastes and for trimmings from the preparation line.

TABLE 3.—General requirements for preparation steps and equipment

Step	Method	Special features	Remarks
Feeding to preparation line	By conveyor, or manually with hand trucks.	Provide large hopper or soaker washer to insure continuous feed along the preparation line.	Preliminary sorting may be done on the conveyor. Front end of line usually very dirty; advisable to install a dry-cleaner ahead of the line.
Peeling	Abrasion and flame peelers are used. Other expedients have been tried. Hand peeling probably best but most costly.	Peel removed after flame peeler by high-pressure washer, by shaker-washer, or by brush washer.	A presizer is advisable if abrasion peeling is used.
Trimming	By hand, women standing alongside conveyor belt.	Merry-go-round feature has many advantages. Provide good lighting.	Provide about 3 feet of space along belt for each woman. 30 inches is a desirable minimum.
Washing	By a continuous rotary washer.		
Cutting	By a continuous cutter which will slice, strip, or dice the vegetable as desired.	Provide screen and magnets ahead of the cutter to remove foreign objects such as bolts, rocks, etc.	Elevator to cutter may be equipped with water sprays.
Waste disposal	Settling tanks, sewerage separators, grinders, etc.	Conveyor from trimming table to carry trimmings.	

Table 3 presents a summary of operating steps in the preparation of raw material for drying with a brief description of salient points to be considered in choosing the equipment.

Choice of drier.--Three types of vegetable dehydrators are shown in figures 2 and 4 to 6. Figure 2 shows a plant capable of handling 50 tons of raw product per day, in continuous operation. The dehydrator is of the multistage tunnel type. Figure 4 shows a 25-ton plant with a counterflow tunnel drier and figure 5, a conveyor drier. All are planned to include finishing bins.

This presentation is not meant to imply that a multistage unit is better for a 50-ton plant, and a conveyor type for a 25-ton plant. In fact, a straight counterflow tunnel may be better for onions than either type. The examples are presented for illustrative purposes only and it is probable that each of these types will be used in the future in a wide range of plant capacities. The capacities indicated are only nominal; the true capacity of each is dependent upon the product, the drier design, heat input and air circulation, and the use of finishing bins.

In the multistage drier, the material passes first through a parallel-flow tunnel, then through a counterflow tunnel, and finally into finishing bins. If properly designed, this is a very flexible type of unit, permitting the adjustment of drying conditions to the optimum for product quality. The second-stage tunnels, used alone, are suitable for fruit drying.

Drying times in counterflow tunnels are not as short as in multistage units because the maximum temperature of the air is limited by the highest temperature that the product at the dry end can stand. The use of finishing bins, permitting removal of the product from the tunnels at a higher moisture content, partially offsets this drawback.

The conveyor type of drier shown in the 25-ton plant has shown promise in commercial operation and will doubtless be used increasingly as its operating problems are overcome.

Figure 6 shows the layout for a plant handling 400 pounds of raw product per hour. If the operation is continuous, the plant will process about 5 tons of vegetables per 24 hours. The dehydrator is a 9-truck tunnel of small cross section, and it is assumed that one truck will be loaded every 50 or 60 minutes. The preparation line will probably be operated only one or two shifts per day; the drying will therefore continue only until all the product in the tunnel has been dried.

These smaller plants are not usually in a commercially competitive position unless they have some special advantages, such as low-cost raw material or low-cost labor. Small plants, operating as community projects or on individual farms, often justify themselves by making possible the saving of crops that have no ready market. Their value in wartime is limited by the fact that the output per unit of operating labor and construction materials is low.

The operation of plants much smaller than those handling 25 tons per day is likely to be intermittent, and batch-type driers or tunnels smaller than the usual commercial type may, therefore, be preferable. The use of tunnel-type driers in a discontinuous operation is feasible only if close control of temperature and humidity is maintained during the starting-up and shutting-down periods.

The choice of drier may be influenced by the amount of labor required. Although the output per dollar of investment for a conveyor dehydrator is generally less than for a tunnel drier, the lower labor cost in operating the former may offset the higher initial capital cost. If tray-type driers are used, all practical labor-saving methods and devices should be installed. Tray handling and washing may entail a considerable amount of hand labor, whereas belt cleaning may be almost entirely automatic. When labor rates are high, the re-handling costs involved in multistage drying may be sufficient to cause a reconsideration of the system to be installed. Automatic movement of the cars in and between the tunnels may overcome this disadvantage.

It may not be possible, however, to determine which type of dehydrator is preferable on the basis of cost alone. It is probable that the choice will be determined mainly by availability of construction materials and operating labor and the quality and quantity of output.

Tunnel driers require considerable floor space because of the need for transfer trucks, car tracks, car and tray storage, tray washing equipment, and the tray conveyors used in loading. The conveyor-type drier requires relatively little floor space in addition to that occupied by the drier itself. Through circulation of air permits heavy loading on the belt, thus reducing its required size and minimizing needed floor space.

The upkeep of the drier is important. The cost of maintaining the trays in proper condition can be balanced against the upkeep of a large and costly belt or conveyor. Careful handling and proper maintenance lengthen the life of either type of equipment.

Ample capacity in the dehydrator is usually a good investment. Since the fuel and power costs are relatively low, an increase or decrease of even a substantial percentage does not seriously affect the total processing cost. Increased labor costs due to inefficient use of labor in the preparation line, when the dehydrator is unable to handle the output of the line, usually amounts to far more than any additional drying cost resulting from the use of a slightly oversized dehydrator.

Finishing bins used in conjunction with the dehydrator make it possible to utilize the full capacity of the dehydrator proper by shortening the time of the main drying operation. This shortening of drying time may result in an improvement in quality. The overall cost per unit of drying capacity will usually be less when finishing bins are used.

It will be noted that only air-blast driers are considered. The principal reasons for this restriction are that air drying is a proved method and that it generally gives the greatest output of product for a given quantity of critical construction materials. Various combinations of vacuum, radiant heat, and other drying aids may find increasing use as material shortages become less acute if dried products of superior quality can be produced by these other methods.

Loading and stacking trays.--One tray line should ordinarily be adequate for plants handling up to 100 tons per day. Proper timing of tray loading, stacking, drying, and tray scraping is essential for efficient operation. This is especially true for large plants. At least 10 to 12 seconds should be allowed for handling each tray at the loading point although the actual time involved in taking the tray from the loading table and placing it on the truck is somewhat less than this. On this basis, a 100-ton plant is near the limit for one tray line. It should be borne in mind that if the rate is increased so that the handling time is less than 10 to 12 seconds per tray or if the flow of product is not uniform, two tray lines will be necessary.

Spreading the product on trays is slightly more difficult than spreading on a flat belt because the sides of the trays are higher than the material. Leafy vegetables, such as unblanched shredded cabbage, are an exception since this material is stacked higher than the sides of the trays. Several suggested means of spreading on trays are sketched in figure 7.

It is important that tray handling be avoided wherever possible. One possibility is in the following arrangement: After the trays are scraped and dumped, they are placed immediately on a tray conveyor which takes them back to be loaded again. Tray cleaning can be accomplished on this conveyor by means of high-pressure, hot water sprays, revolving brushes, etc. A car standing alongside the conveyor can be used to furnish extra trays for loading when necessary. Two conveyors in series, the first running at a faster speed, help to maintain a continuous line of trays for loading. If this system is used, tray scraping and tray loading must be coordinated for efficient operation.

Packaging equipment.--The packaging room should be enclosed, thus excluding damp air from the preparation room and dehydrator. Air desiccating equipment is advisable in many cases. If a refrigeration system already is available, desiccation based upon refrigeration can be used. Where no such equipment exists, nonrefrigerative types are generally installed. When a product is dried to an extremely low moisture content, desiccation of air is essential and will more than pay for itself in improving the quality of the packaged material.

Where a shaker-sieve is used to remove the fines from the dried product, the economical use of these fines is a problem. If the quantity is large, installation of grinding equipment may be advisable. The necessity for grinding equipment also depends largely upon the demand for soup stocks, purees, and seasonings. Onions, celery, and garlic have been quite generally prepared in powder form, and powdering equipment will probably continue to find its greatest use for these vegetables. An extremely dry product and dry air are essential in any powdering operation.

If the product is packaged in 5-gallon cans, packaging equipment costs are very moderate. The can sealer is rented on a yearly basis at an extremely low rental fee, and only boxing or crating tools are required in addition. Other types of packaging usually require special equipment which in most cases is more expensive to install and operate. If the product is compressed before packaging, special techniques such as those described in AIC-5 will be involved.

Handling capacities and utility requirements.--The capacities per unit of time at various points along the processing line for the various sizes of plants are given in table 4. Such tables are of assistance in estimating labor requirements and equipment sizes for each operation. Although the operations are considered continuous, employees actually work less than 8 hours per shift because of time out for lunch and relief periods. An operating time of 7 hours per shift, or 21 hours per day, has been assumed.

Facilities must be available to provide approximately the quantities of heat, power, and water indicated in table 5. Direct-fired heat is assumed for the tunnel dehydrators, and steam heat for the conveyor drier.

The figures in this table allow for the difference in consumption of utilities under various operating conditions. The indicated demand load for electric power is really total connected load. The average operating load will be smaller.

Labor Requirements

Labor costs are so important in dehydration that efficient use of labor is essential if reasonable operating costs are to be attained. The number of employees in a dehydration plant is by no means fixed, and preliminary estimates of labor requirements are usually rough approximations because of the large number of factors affecting labor usage. Among these factors are: type of process, degree of mechanization, efficacy of equipment, effectiveness of plant layout, proper balance between operating steps, condition, variety, and grade of raw material, specification for finished product, labor laws and customs, working conditions, ability and training of employees, method of pay, morals, and operators' individual preferences and policies. Not all of these factors can be evaluated in advance. The discussion presented here has been largely based upon observations made in canneries and dehydration plants and the opinions of experienced plant operators.

Table 6 shows the approximate labor distribution in dehydration plants of various sizes. The trimming, sorting, and inspection labor in commercial-size plants varies in almost direct proportion to the size of the plant. Thus, a 100-ton plant drying onions can be expected to require from 50 to 70 women on the trimming belt; a 50-ton plant, 25 to 35. This direct relation does not hold true for the other operations. As size of plant increases, the labor requirement per unit of output for these other operations decreases. Because of the need for at least one or more employees for each of many operations regardless of the throughput at those points, the smaller plants are at a disadvantage as compared with the larger ones which can make more efficient use of labor.

The method of peeling materially affects the number of trimmers needed and must be thoroughly investigated before deciding upon the type of peeler, if any, to install.

TABLE 4.--Operating capacities per unit of time
(operating 21 hours per day)

	5-ton plant	25-ton plant	50-ton plant	100-ton plant
Unprepared Basis:				
Pounds per hour	475	2,400	4,750	9,500
" " minute	8	40	80	160
Prepared Basis: (10% peeling & trimming loss)				
Pounds per hour	430	2,145	4,290	8,570
" " minute	7	36	72	145
Number of women trimming	4	15	30	60
Pounds per woman per minute	1.8	2.4	2.4	2.4
Pounds per tray--@1¼ lbs. per sq. ft.	15	22.5	22.5	22.5
" " car of 22 trays	330	495	495	495
Cars per hour 1/	1.3	4.3	8.7	17
Minutes per car	46	14	7	3.5
Trays per hour 1/	29	95	190	380
" " minute	0.5	1.6	3.2	6.4
Seconds per tray	120	38	19	9
Dried Basis:				
Overall shrinkage ratio--11 to 1 2/				
Pounds per day	900	4,500	9,000	18,000
" " hour	43	220	430	870
" " minute	0.7	3.7	7.2	14.4
Packages per day (12 lbs. per package)	76	380	760	1,520
" " hour	3.6	18	36	72
Minutes between packages	17	3.3	1.7	0.8

1/ The number of trays and cars handled is based upon the total weight of trimmed material. The actual weight handled will decrease during washing and cutting, because of leaching and loss of fines. On the basis of the loadings indicated here, the number of trays and cars handled will, therefore, be somewhat less than shown in the table.

2/ Overall shrinkage ratio is the ratio of weight of unprepared raw material to the resultant weight of dried product. This ratio for onions may vary from 8 to 1 to 14 to 1, depending on variety and condition of the raw material. The ratio of 11 to 1 has been adopted for estimating purposes only.

TABLE 5.--Approximate utility requirements

Utility and application	25-ton plant 1/	50-ton plant 1/	100-ton plant 1/
Water		Gallons per hour	
Potatoes and sweetpotatoes	2,500 to 5,000	5,000 to 10,000	10,000 to 20,000
Carrots, beets, rutabagas, and onions	2,000 to 4,000	4,000 to 8,000	8,000 to 16,000
Cabbage	600 to 1,000	1,200 to 2,000	2,500 to 4,000
Electricity		Kilowatts	
Demand load	50 to 70	80 to 125	150 to 250
Fuel		B. T. U. per hour 2/	
Dehydrator			
Direct heat	$3\frac{1}{2}$ to 5 million	$7\frac{1}{2}$ to 10 million	15 to 20 million
Indirect heat	8 to 13 million	15 to 25 million	30 to 50 million
Steam heat	5 to 8 million	10 to 15 million	20 to 30 million
Blancher 3/ and incidental	1 to 2 million	2 to 4 million	4 to 8 million
Boiler capacity		B. H. P. (actual) 2/	
Blanching and incidental	25 to 50	50 to 100	100 to 200
Dehydrator	125 to 175	250 to 350	500 to 700

1/ Capacity given in tons per 24 hours, unprepared basis.

2/ The lower limits of heat requirement and boiler capacity for the dehydrator are considerably larger than needed for some vegetables under good operating conditions. On riced white potatoes, for example, the minimum heat requirement may be less than two-thirds of that indicated in the table.

3/ Low limit is based on continuous type blancher. If batch type blancher is used blanching steam demand will be higher.

TABLE 6.--Estimated labor requirements

	Number of employees per shift 5-ton plant	25-ton plant	50-ton plant	100-ton plant
Direct labor[1]:				
Feed to preparation line	1 M	1 M	1-2 M	2-3 M
Operating peeler			0-1 M	0-1 M
Sorting and trimming	3-6 F	15-20 F	25-35 F	50-70 F
Placing trays on conveyor		1 M	1 M	1-2 M
Spreading on trays		1-2 F	1-2 F	2-4 F
Loading cars	1 M	2 M	2 M	2-4 M
Moving cars and operating drier		1 M	2 M	3-4 M
Scraping trays)		2 M	2-4 M	4-6 M
Final inspecting)	1 F,	2-5 F	4-8 F	8-16 F
Packaging, crating and warehousing[1])	1 M	2 F, 2 M	3-4 F, 2-3 M	4-6 F, 3-5 M
Other:				
Foreman	1	1	1	1
Forewoman			1	1
Helpers, cleanup, maintenance, etc.	1 M	2-4 M	4-6 M	8-12 M
Total per shift:				
Men	4	11-13	14-21	23-37
Women	4-7	20-29	33-49	64-96
Foreman	1	1	1	1
Forewoman	-	-	1	1
Indirect labor:				
Bookkeepers)			1-2	2-3
Stenographers)	1	2-3	1	1-2
Payroll and other clerks)			1-2	2-4
Superintendent)		)	1	1
Field man)	1	) 1	1	1
Plant chemist (and assistants))		1	1	1-2
Total, one shift per day	2	4-5	6-8	8-13

1/ Labor requirements for packaging depend on type of container used. Labor figures shown here are based upon the use of five-gallon cans, automatic sealing machine, and prefabricated cartons, boxes, or crates. The use of metal foil containers or other types of packages will involve a different labor set-up.

The type of drier affects labor requirements. A 50-ton tunnel drier requires from 10 to 15 employees per shift for loading and stacking trays, moving cars, operating the drier, scraping trays, and washing trays. If a conveyor-type drier is used instead, and a suitable mechanical arrangement is available for spreading the product evenly over the conveyor belt, from 2 to 4 employees per shift may be necessary to handle the drying operations in a plant of the same size

An estimate of probable labor costs is presented in table 7. Careful analysis shows that the small plants are at a decided competitive disadvantage when compared with the larger ones.

Estimated Construction Costs

Estimates of building and equipment costs are shown in tables 8 and 9. These costs must be considered as rough approximations since they cannot possibly include all items. Even a plant that has been completely engineered before construction may present the owner with additional cost items before it is finished. Conditions vary throughout the country, and these variations materially affect any attempt to arrive at generalizations regarding costs.

Low and high estimates of cost are given. There is only a remote likelihood that any plant will or should be constructed at a minimum of cost for all items. Unless constructed under unusual circumstances, such a plant would probably experience operating difficulties due to lack of equipment and limited floor space. Dehydration plants should be balanced units, and the costs of various parts will be low or high in accordance with the circumstances affecting each particular machine, operation, or floor space requirement.

Estimated Processing Costs

Table 10 presents a partial summary of estimated processing costs for dehydrating onions. The cost elements included are raw material, direct and indirect labor, packaging, and utilities.

Other indirect and overhead costs have not been included in this calculation. Some operators believe that total overhead costs should not average more than 50 percent of direct labor, while others say that these costs may be equal to or even greater than the cost of direct labor. Still others believe that overhead costs have no relation to labor and cannot be accurately estimated on a labor basis. Wide variations occur from plant to plant due to the fact that overhead costs in vegetable dehydration depend on such factors as the length of operating season, cost of buildings and equipment, local conditions, and managerial policies. The complexity of these interrelated factors is such that no general estimates of overhead cost have been attempted.

The cost figures, although not complete, are useful guides within the indicated limits. A prospective operator can combine these figures with data specifically relating to his proposed operation and thus more accurately estimate what his costs are likely to be.

The figures are based upon continuous operation, a phenomenon rarely experienced in commercial plants. Where operations are interrupted or are discontinuous, suitable corrections must be applied. It is apparent, also, that the cost estimates must be adjusted in any particular situation according to labor rates, shrinkage ratios, and operating procedures.

TABLE 7.--Estimated labor cost per dry pound

	5-ton plant	25-ton plant	50-ton plant	100-ton plant
Average hourly output per 24-hour day, dry basis 1/	38 lbs.	190 lbs.	380 lbs.	760 lbs.
Direct labor cost per hour				
Men - 75¢ per hour	$ 3.00	$ 8.25- 9.75	$10.50-15.75	$17.25-27.75
Women - 60¢ per hour	2.40-4.20	12.00-17.40	19.80-29.40	38.40-57.60
Foreman	1.00	1.25	1.25	1.50
Forewoman	-	-	.85	1.00
Total	6.40-8.20	21.50-28.40	32.40-47.25	58.15-87.85
Indirect labor, cost per hour				
Bookkeepers - 75¢/hr.)			.75-1.50	1.50-2.25
Stenographers - 65¢/hr.)	.75	1.40- 2.15	.65	.65- 1.30
Payroll and other clerks - 75¢/hr.)			.75- 1.50	1.50- 3.00
Superintendent)		)1.50	1.50	1.75
Field man)	1.25	)	1.25	1.50
Plant chemist (and assistants))		1.00	1.25	1.25- 2.50
Total	2.00	3.90- 4.65	6.15- 7.65	8.15-12.30
1/3 applicable to each of 3 shifts	.70	1.30- 1.55	2.05- 2.55	2.70- 4.10
Total labor cost per hour	$7.10-8.90	$22.80-29.95	$34.45-49.80	$60.85-91.95
Labor cost per dry pount	18.5-23.5¢	12.0-16.0¢	9.0-13.0¢	8.0-12.0¢

1/ Assumed overall shrinkage ratio is 11 to 1.

TABLE 8.--Estimated cost of preparation, final inspection and packaging equipment

Equipment	5-ton plant		25-ton plant		50-ton plant		100-ton plant	
	Low	High	Low	High	Low	High	Low	High
Preparation equipment								
Hand trucks	$ 15	$ 25	$ 50	$ 100	$ 100	$ 150	$ 100	$ 200
Conveyors	-	-	500	800	800	1,000	1,000	1,500
Elevators	-	-	500	700	600	800	800	1,000
Peelers 1/	200	500	1,000	5,000	2,000	7,500	3,000	10,000
Peel removers	-	-	300	600	400	800	500	1,000
Trimming tables or belts	50	100	1,200	2,500	2,000	4,000	4,000	8,000
Washer-elevators	-	-	500	700	600	800	800	1,000
Washers	50	200	600	800	1,000	1,200	1,100	1,400
Cross-conveyors	-	-	200	300	300	400	400	500
Cutters	500	600	700	1,000	700	1,000	1,500	2,000
Total	815	1,425	5,550	12,500	8,500	17,650	13,200	26,600
Final inspection and packaging equipment								
Hoppers and shaker sieves	50	100	300	500	400	600	400	600
Inspection belts	-	-	400	600	600	1,000	1,000	1,400
Hoppers, scales and packaging equipment	100	150	300	600	400	800	500	1,000
Roller conveyor	-	-	200	400	250	500	400	600
Hand trucks and tools	50	100	100	200	150	300	250	400
Total	200	350	1,300	2,300	1,800	3,200	2,550	4,000
Total cost of equipment	1,015	1,775	6,850	14,800	10,300	20,850	15,750	30,600
Approximate installation Costs (25% of equipment)	250	450	1,700	3,700	2,600	5,200	3,950	7,650
Total cost installed	$1,265	$2,225	$8,550	$18,500	$12,900	$26,050	$19,700	$38,250

1/ The range of peeler costs includes abrasive peelers and flame or radiant heat peelers.

TABLE 9.--Approximate building and equipment costs

Item of plant	5-ton plant Low	5-ton plant High	25-ton plant Low	25-ton plant High	50-ton plant Low	50-ton plant High	100-ton plant Low	100-ton plant High
Preparation, final inspection, and packaging equipment	$ 1,300	$ 2,200	$ 8,500	$18,500	$13,000	$ 26,000	$ 20,000	$ 38,000
Drying equipment	8,000	12,000	20,000	25,000	40,000	50,000	80,000	100,000
Building space at $1 per sq.ft.	3,000	5,700	13,000	21,000	22,000	35,000	36,000	60,000
Sewerage	-	-	1,000	2,000	2,000	3,000	3,000	4,000
Office and laboratory equipment	100	500	500	1,000	500	2,000	1,000	3,000
Machine shop, tools and equipment	100	200	250	500	500	1,000	500	1,500
Total cost	$12,500	$20,600	$43,250	$68,000	$78,000	$117,000	$140,500	$206,500
Cost per ton of daily capacity (unprepared basis)	$ 2,500	$ 4,100	$ 1,700	$ 2,700	$ 1,600	$ 2,400	$ 1,400	$ 2,100

TABLE 10.--Estimated costs of producing dehydrated onion slices exclusive of overhead costs and profits

	Cost per dry pound[1]			
	5-ton plant	25-ton plant	50-ton plant	100-ton plant
	Cents per dry pound			
Processing costs per dry pound				
Labor, direct and indirect [2] (from table 7)	18.5-23.5	12.0-16.0	9.0-13.0	8.0-12.0
Containers [3]	3.5	3.5	3.5	3.5
Utilities	1-2	1-2	1-2	1-2
Total	23.0-29.0	16.5-21.5	13.5-18.5	12.5-17.5
Raw material costs per dry pound				
Cost at $30. per ton	16.5	16.5	16.5	16.5
" " $35. " "	19.5	19.5	19.5	19.5
" " $40. " "	22.0	22.0	22.0	22.0
" " $45. " "	25.0	25.0	25.0	25.0
" " $50. " "	27.5	27.5	27.5	27.5
Total costs per dry pound not including overhead costs or profit				
Raw material @ $30/ton	39.5-45.5	33.0-38.0	30.0-35.0	29.0-34.0
" " @ $35/ton	42.5-48.5	36.0-41.0	33.0-38.0	32.0-37.0
" " @ $40/ton	45.0-51.0	38.5-43.5	35.5-40.5	34.5-39.5
" " @ $45/ton	48.0-54.0	41.5-46.5	38.5-43.5	37.5-42.5
" " @ $50/ton	50.5-56.5	44.0-49.0	41.0-46.0	40.0-45.0

1/ Assumed overall shrinkage ratio is 20 to 1.

2/ The low limit of labor cost is a summation of the low estimates for each individual operation, as shown in table 6; it is very unlikely that any plant will operate with an absolute minimum of labor in all operations.

3/ The cost of containers includes 25 cents for a single 5-gallon can holding 12 pounds of onions and 30 cents for the wire-bound wood box holding two cans; the total per can is 40 cents. This item should be adjusted if other containers are used.

FIGURE I

DEHYDRATION FLOW SHEET

FOR

ONIONS

(NOT SCALED)

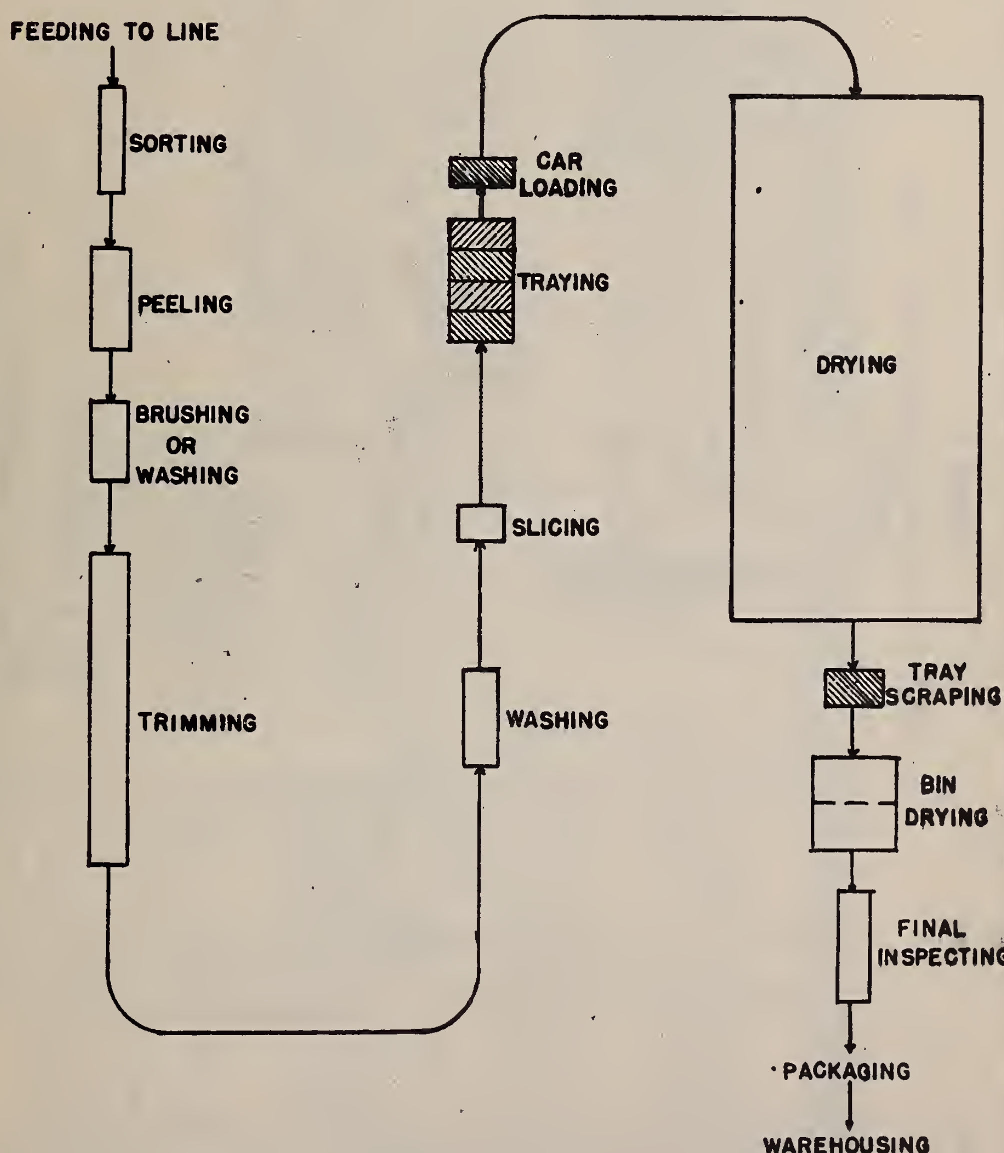


FIGURE 2
LAYOUT OF 50-TON DEHYDRATION PLANT
(ONIONS)

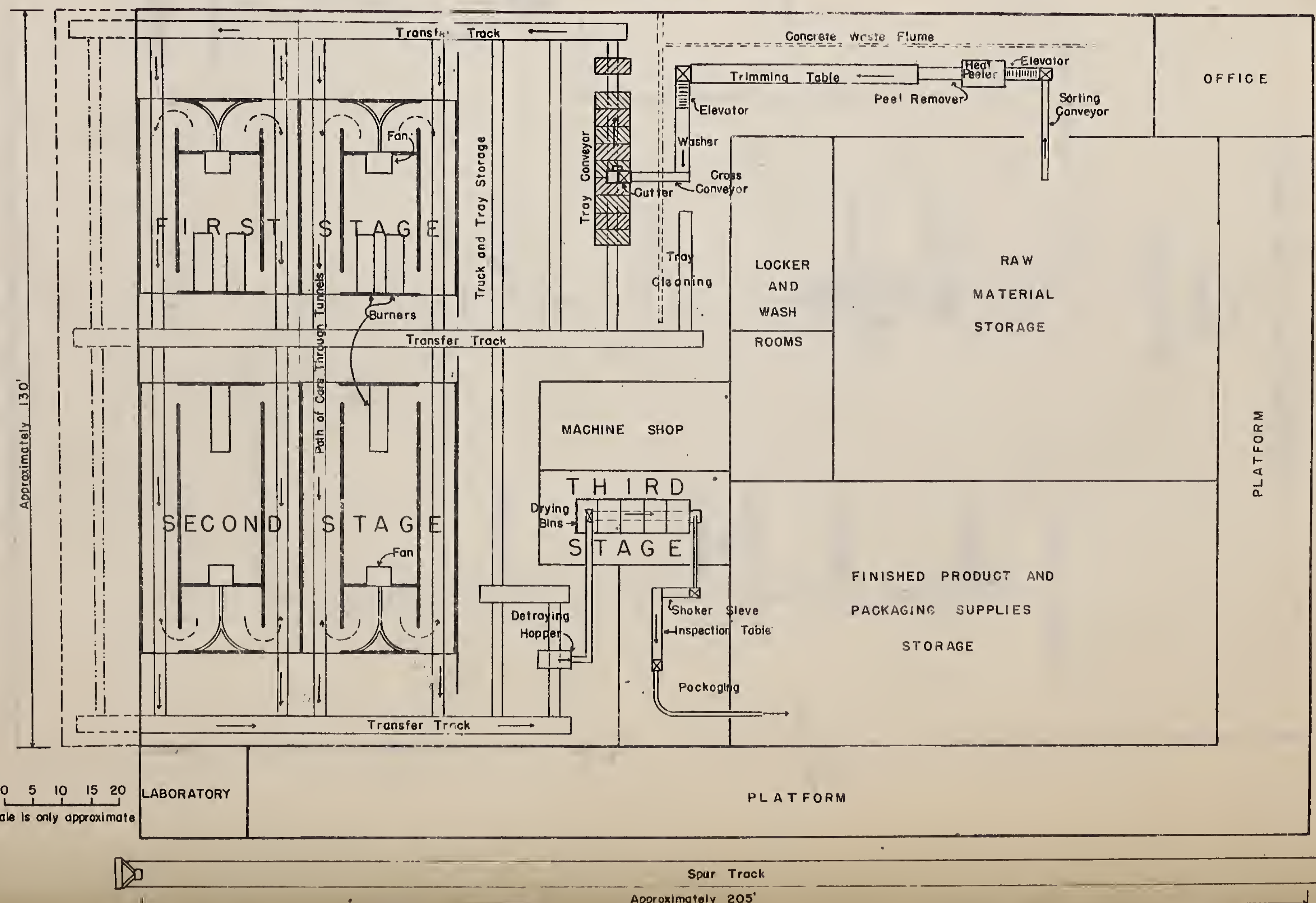


FIGURE 3

PREPARATION LINE FOR 50-TON DEHYDRATION PLANT

(ONIONS)

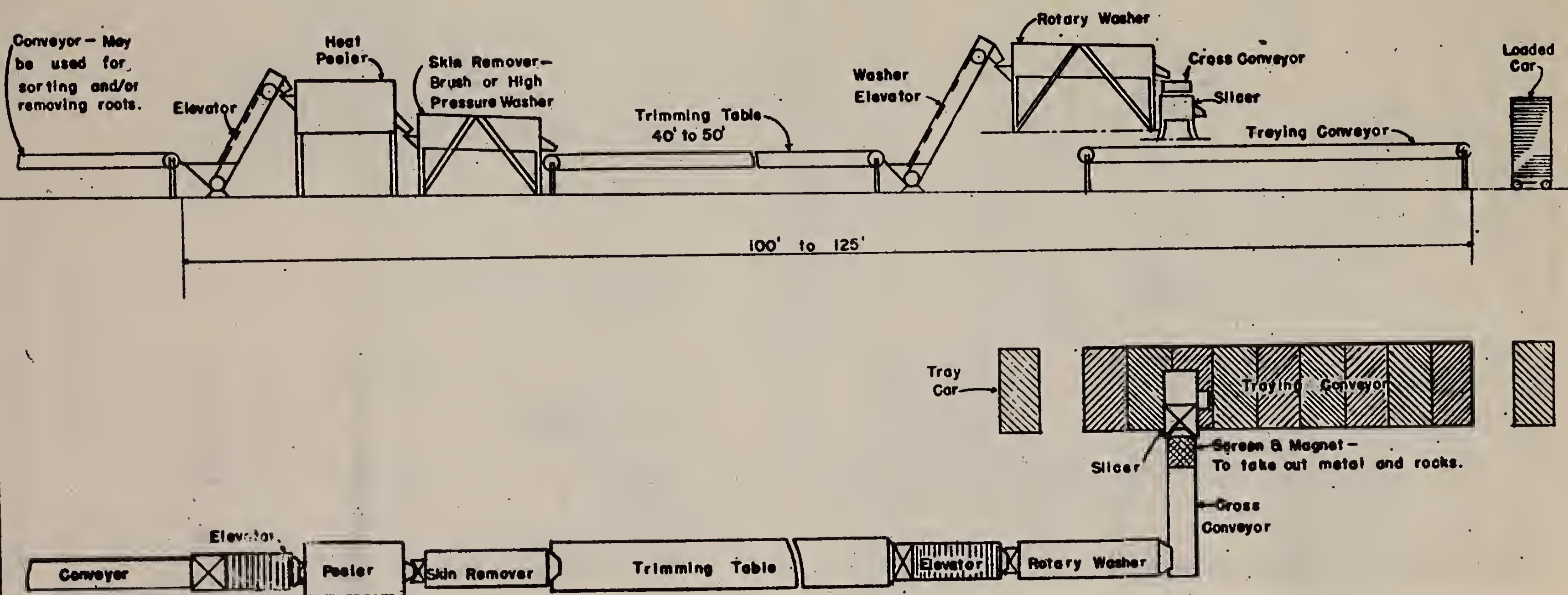


FIGURE 4

LAYOUT OF 25-TON DEHYDRATION PLANT-TUNNEL TYPE

(POTATOES, CARROTS, AND RUTABAGAS)

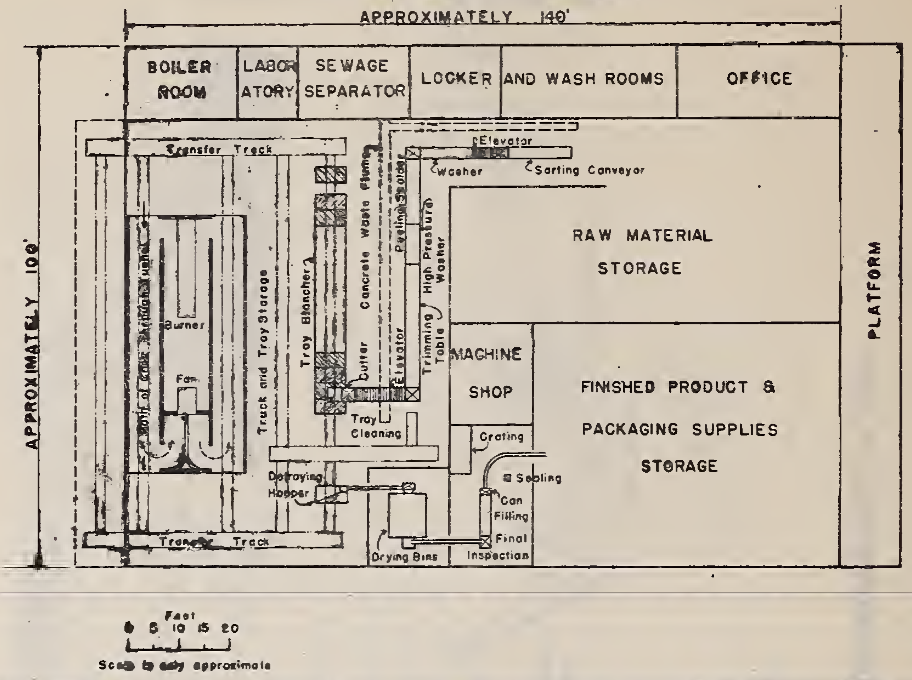
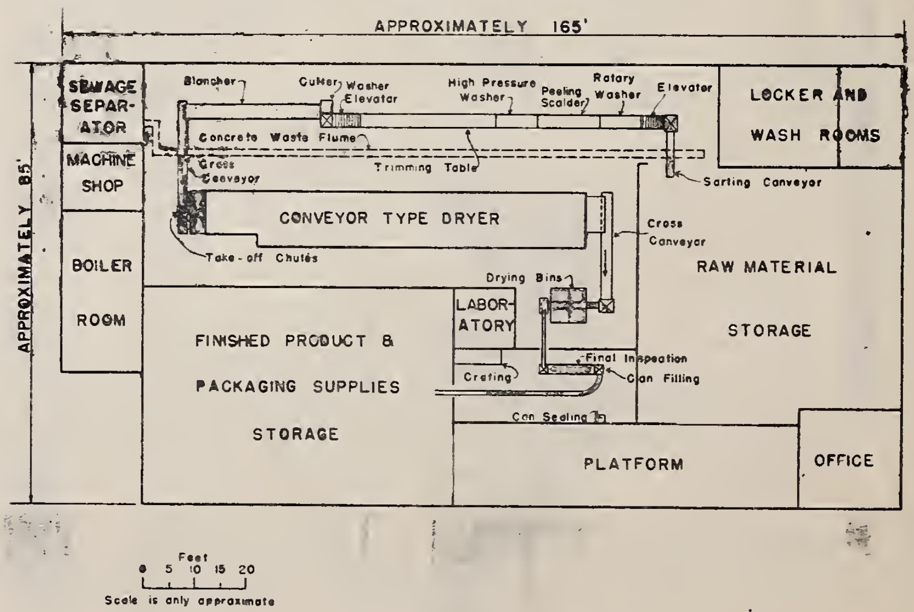


FIGURE 5

LAYOUT OF 25-TON DEHYDRATION PLANT-CONVEYOR TYPE

(POTATOES, CARROTS, AND RUTABAGAS)



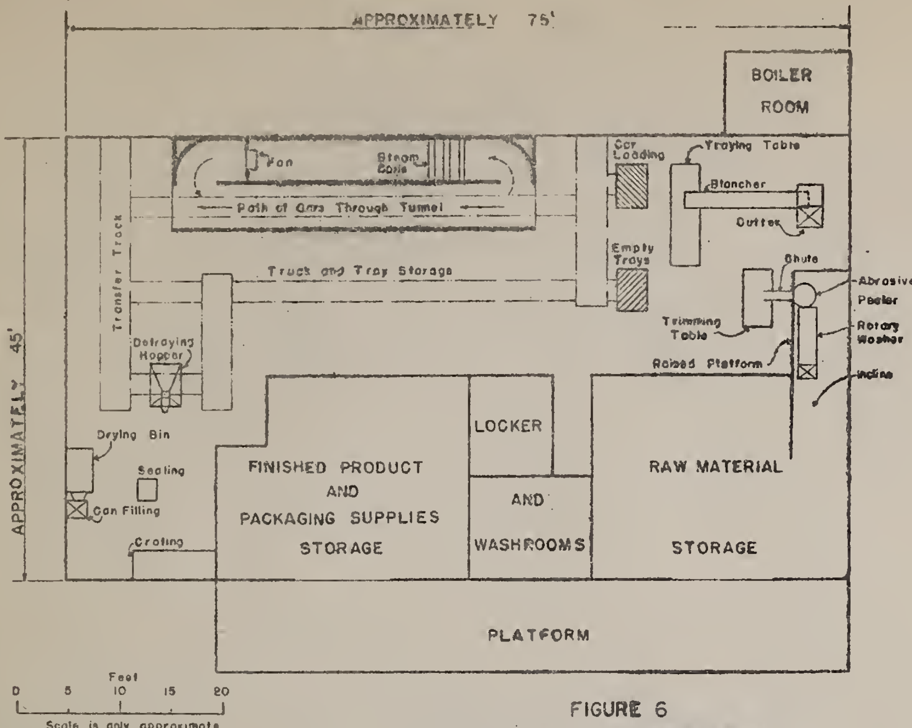


FIGURE 6

LAYOUT OF 5-TON DEHYDRATION PLANT

(POTATOES, CARROTS, AND RUTABAGAS)

FIGURE 7

METHODS FOR OBTAINING UNIFORM SPREADING ON DRYING TRAYS